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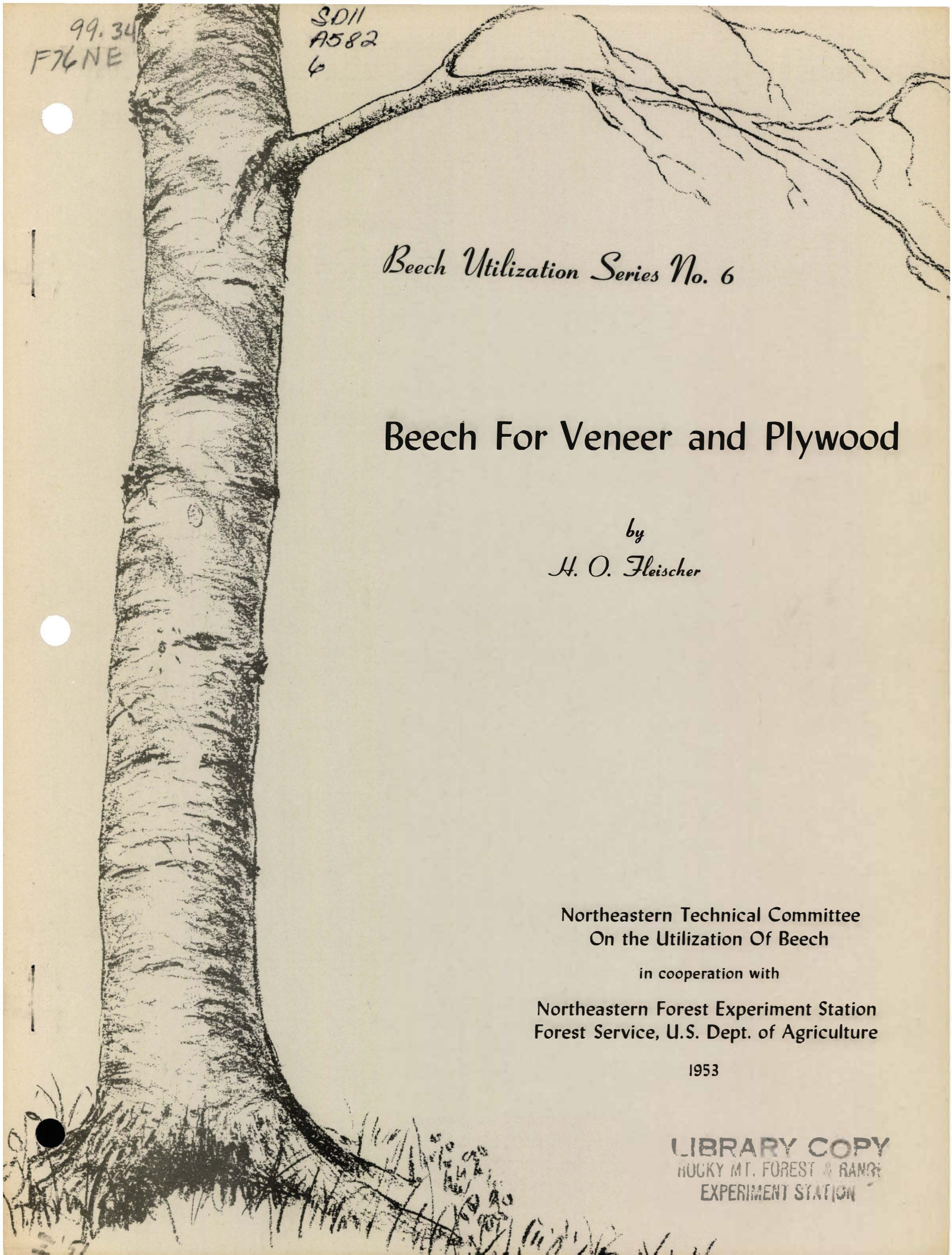

Beech Utilization Series No. 6

Beech For Veneer and Plywood

by

H. O. Fleischer

Northeastern Technical Committee
On the Utilization Of Beech

in cooperation with

Northeastern Forest Experiment Station
Forest Service, U.S. Dept. of Agriculture

1953

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FOREWORD

The wood of the American beech tree (Fagus grandifolia Ehrh.) is well suited for a large number of uses, and it is rather widely used by manufacturers. Yet the amount used is not in proportion to the amount that grows in our northeastern forests. The utilization of beech--both in the woods and in the factory--has been recognized as a problem.

One reason for this is in the nature of the wood: it has a reputation for being difficult to season. Another is that many of the beech trees in our forests are of poor quality. And there are some plain prejudices against beech.

Research is finding ways to utilize beech as efficiently as any of the other comparable hardwoods can be handled. Considerable information about beech has been gathered. Yet most of this information is available only in fragmentary form in scattered technical reports. Some of it has never been published.

To study the problems of putting beech to the uses it deserves, and to promote the better management of the forests in which it grows, a Northeastern Technical Committee on the Utilization of Beech was organized in 1949. This committee, which includes representatives of Federal and State forestry agencies, universities, and state experiment stations, decided to assemble and publish the available information about the utilization of American beech.

As its part of this cooperative project, the Northeastern Forest Experiment Station has undertaken to edit, publish, and distribute the series of reports that will contain this information.

The subjects of these reports will be as follows:

* Physical and mechanical properties of American beech.

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BEECH FOR VENEER AND PLYWOOD

by

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INTRODUCTION

AMERICAN BEECH (Fagus grandifolia) has been used successfully for veneer and plywood on a moderate scale for many years. Many veneer producers throughout the eastern United States have at one time or another cut beech into veneer and have been pleased with the resulting product. There is complaint, however, that the proportion of beech logs of veneer quality is relatively small, and this appears to be the main deterrent to a wider acceptance of the species by the veneer and plywood industry.

This report will not attempt to deal with the supply of beech veneer logs. It is intended to cover, rather, the technical aspects involved in selecting and preparing beech veneer logs, rotary cutting of the wood on the lathe, veneer drying, plywood fabricating problems, and properties and uses of the finished products.

Data presented here were obtained from laboratory tests, from industry surveys, and from available literature on the subject, both American and European.

[1] MAINTAINED AT MADISON, WIS. IN COOPERATION WITH THE UNIVERSITY OF WISCONSIN.

SELECTION OF VENEER LOGS

Beech is a close-grained wood with distinct growth rings, small pores, and many prominent rays. It is relatively hard and heavy, is frequently straight-grained, and has a uniform texture. The tree is slow of growth and frequently has heavy branches. It is reportedly susceptible to heart rot and frost cracks. Second-growth timber is said to develop straighter stems, to be more free of limbs, and to have a higher percentage of white sapwood than old-growth timber (9).[2]

Peeler-Log Grade

Among the features that are considered desirable in the selection of logs for veneer cutting are a relatively large diameter, freedom from knots and other surface defects that indicate interior defects, freedom from ring shake and internal splits, freedom from crook and sweep, and freedom from decay. With regard to these defects, many mills follow their own rules in selecting logs for veneer. There are, however, accepted grading rules for hardwood logs that may be applied to beech veneer logs (1).

According to these rules a No. 1 or veneer-grade log must be 12 inches or more in diameter. (Surface-clear logs 12 feet or longer may be 11 inches.) Standard lengths are 10, 12, 14, and 16 feet--with a 3- to 4-inch trim allowance. Logs must be reasonably straight-grained, and spiral grain must not exceed 1 inch in 10.

Standard defects limited by these rules are knots, worm holes, shake, cat-face, dead and dozy spots, seams, bird pecks, brown spots, pinholes, and pin knots. Ten-foot logs must not have more than one standard defect, 12-foot logs not more than two, and 16-foot logs not more than three. Several standard defects located so that they can be cut out with a 1-lineal-foot deduction are considered as one defect.

Limitations with regard to center holes, doze, and shake vary with the log diameter, with defects of 3 to 6 inches in diameter being permitted. Seams are not permitted in logs 15 inches and less in diameter; larger logs may have

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[2] UNDERLINED NUMBERS IN PARENTHESES REFER TO LITERATURE CITED, PAGE 23.

a straight, tight seam. Seams and other defects in the swelled portions of butt logs, that do not extend into the rounded cylinder portion of the log, are not considered defects.

Provisions are also made in the log-grading rules for short or odd-length logs, and for reduction in scale of logs containing other than the standard defects.

Test Logs Used

In a veneer-cutting study conducted at the Forest Products Laboratory, 10 beech logs 8 to 10 feet long were rotary-cut into veneer on an experimental basis. The logs were obtained from Oswego Reforestation Area No. 2, near Lacona, N. Y., through the cooperation of the New York State Conservation Department and the Northeastern Forest Experiment Station. They were selected from a mixed hardwood stand that had been high-graded about 1903 so that old beech and cull maples were left as the dominant trees. The local District Forester believes the logs, although not of the best, were representative of the better-quality beech logs available in the District.

The logs ranged in diameter (inside bark, small end) from 13 to 16 inches. Some were butt logs and had considerable taper. Ring counts on all logs indicated ages of 80 to 160 years. Growth rates varied from 6 to 48 rings per inch. The logs were fairly round and concentric. Sapwood was $1\frac{1}{2}$ to $3\frac{1}{2}$ inches thick.

All of the logs met the requirements for the veneer-log grade described above, except one that had heart rot approximately 12 inches in diameter. One other log had a smaller amount of heart rot and two had spiral grain, but these defects were not excessive according to the grading rules.

Tests made on disks cut from the test logs showed that they were relatively homogeneous in density. Specific-gravity averages for the veneer bolts ranged from 0.565 to 0.662 (based on green dimensions and dry weight). The average specific gravity of the test logs was 0.62, which is somewhat higher than the specific gravities of logs in other samples from other areas (14).

Moisture content was much more variable: averages ranged from 46.2 to 64.4 percent for the veneer bolts (based

on oven-dry weight), and the variation within bolts was considerable. There was no consistent difference in moisture content between sapwood and heartwood.

CARE & PREPARATION OF LOGS

Storage

Like logs of many other hardwood species, beech logs are susceptible to rapid deterioration in storage, particularly during the warm season. Consequently, logs that are to be stored for any length of time in a yard before cutting into veneer should be treated to prevent the development of stain, decay, and end-checks.

Toxic chemicals, applied to the log ends shortly after felling and bucking, will effectively prevent stain and decay for limited periods (4). End-sealers may also be used to prevent drying out and checking of the log ends. Good proprietary coating are available, or the user may compound his own from formulas available from the Forest Products Laboratory (12).

The thin bark of beech is easily broken off during logging and transportation of the logs. Areas of wood exposed this way should also be treated to prevent stain, decay, and surface-checking.

Bucking Into Bolts

In bucking the logs into bolts for cutting on the lathe, the natural defects in the logs (such as those mentioned in the log-grading rules) should be considered. A Laboratory study in 1944 showed that two of the more important factors affecting the yield from hardwood veneer logs are sweep and crook. The effect of these factors can be minimized by carefully selecting the straighter logs available for the long bolts required, and cutting the logs that have pronounced sweep or crook into shorter bolts.

In this country veneer logs are generally cut into bolts before heating. The 10 logs used in the veneer study at the Forest Products Laboratory were cut into 26 bolts 36 to 52 inches long.

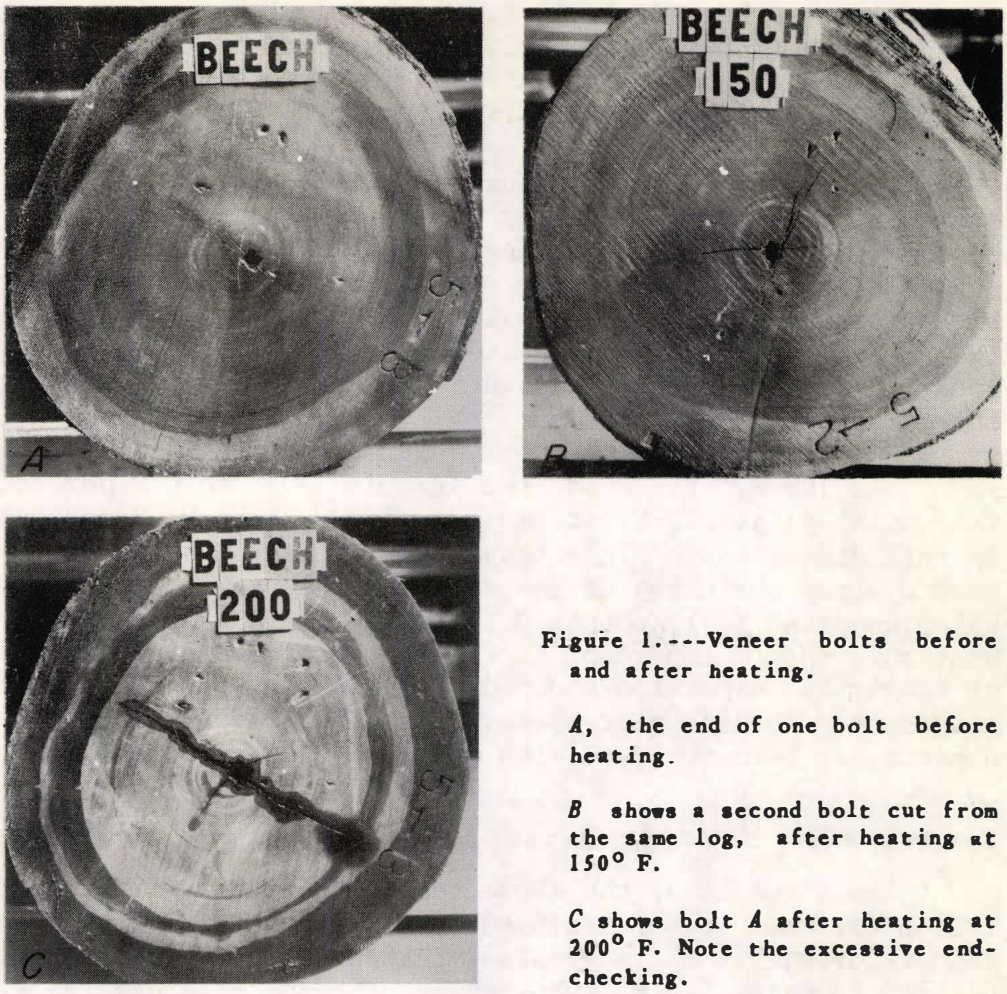

Figure 1.---Veneer bolts before and after heating.

***A*, the end of one bolt before heating.**

***B* shows a second bolt cut from the same log, after heating at 150° F.**

***C* shows bolt *A* after heating at 200° F. Note the excessive end-checking.**

Heating

For the denser hardwoods, heating is essential preparatory to cutting on the lathe. Heating softens the wood--and particularly the knots--so that smooth, tight veneer may be cut.

But during heating, end-checks often develop in the bolts. These result in splits and waste in the veneer. So the effects of heating on beech were studied in the Laboratory tests.

Of the 26 bolts used in the tests, some were cut into veneer without additional treatment; others were heated in water at temperatures of 150°, 175°, 200°, and 210°F. When

the bolts were heated at 150°F., the internal splits that developed were minor. Even at 175°F. the end-checking was not very objectionable. But at the highest temperature the amount of checking was excessive (fig. 1).

Laboratory tests[3] on European beech (Fagus sylvatica) showed that this end-checking was caused by a thermal expansion of the wood in the tangential (circumferential) dimension, which occurred upon rapidly heating green wood to higher temperatures. There was little dimensional change in the green wood when it was heated to 140°F. But heating beyond this temperature caused a progressively increasing thermal expansion.

At 180°F. the wood had expanded 0.1 to 0.2 percent tangentially; at 212°F. it had expanded 0.35 to 0.45 percent in this dimension. This tangential expansion was accompanied by less shrinkage of the wood in the radial dimension, which amounted to less than 0.1 percent at 180°F. and somewhat more than 0.1 percent at 212°F. This combined effect of tangential expansion and radial shrinking upon heating is responsible for the star-checks in the log ends. This phenomenon has been observed with other species of wood too (11).

Recommended Heating Schedules

As a result of the above tests, together with observation of the veneer produced from bolts heated at various temperatures, it is suggested that beech veneer bolts be heated in water at a temperature of approximately 175°F. Heating in water or steaming at a higher temperature may result in an objectionable amount of end-checking and waste.

At this point it may be well to consider some European experiences in heating beech logs for veneer cutting (15). Common practice in Germany is to heat beech (Fagus sylvatica) logs by steaming in pits, using waste steam and maintaining a temperature of 190° to 200°F. This high temperature apparently does not cause an excessive amount of internal checking, perhaps because the wood is heated in long log lengths (20 to 50 feet) rather than in bolt lengths. Since the checking ordinarily is excessive only at

[3] MADE BY GUGLIELMO GIORDANO OF THE SCHOOL OF FORESTRY, FIRENZE, ITALY, WHILE WORKING AT THE FOREST PRODUCTS LABORATORY IN 1950.

the log ends, it is possible by this method to heat the wood to a relatively high temperature without damage to the major part of it.

The length of time required for adequately heating beech veneer logs or bolts depends upon the heating medium, the temperature, the log diameter, and other factors. For certain critical uses such as furniture face veneer it may be necessary to bring the wood to a high temperature (175°F.) throughout. For other uses such as inner plies it may not be necessary to attain a temperature of more than 150°F. at a diameter near that at which cutting stops.

Table 1 shows the approximate time required to heat logs of various diameters to attain a temperature of 150°F. at an 8-inch diameter.

Bark Removal

Beech bark is relatively thin and easy to remove with hand tools. Ordinarily the bark is removed after the bolt has been heated, for heating facilitates the removal of the bark. In Laboratory tests the bark was easily removed even from unheated bolts.

VENEER CUTTING

Industry Experience

All veneer producers consulted who had had experience in cutting beech veneer agreed that it is possible to do a good job of veneer cutting from good beech logs.

Several operators pointed out that the knots are hard and may bend or damage the knife edge, particularly at high speeds. It was also reported that shake occurs occasionally in large logs, and causes breakage and delay at the lathe.

European sources report that beech peels into very thin veneer more readily than birch (15).

Laboratory Tests

The Forest Products Laboratory tests demonstrated that it is possible to cut excellent veneer 1/8 inch or thinner from bolts that have been properly heated to a tem-

Table 1.--Heating schedules for beech logs 8 feet or longer, to attain temperature of 150°F. at an 8-inch diameter

Log diameter (inches)	Required heating period	
	In water at 175°F.	In steam at 212°F.
	Hours	Hours
12	8	4
18	25	16
24	45	31
30	75	52

Table 2.--Veneer-drying schedules for beech, in a mechanical drier

Veneer thickness (inches)	Heart- or sapwood	Drying temperature	Time in drier	Final moisture content
		°F.	Min.	Percent
1/8	Heart	325	10	12-17
	Sap	325	10	3-4
	Heart	325	12	3-4
	Sap	325	12	1-2
	Heart	250	25	6-7
	Sap	250	25	4-5
	Heart	250	30	2-3
	Sap	250	30	1-2
	Heart	175	60	6-8
	Sap	175	60	4-5
1/16	Heart	325	5	3-4
	Sap	325	5	1-2
	Heart	250	7	11-12
	Sap	250	7	3-4
	Heart	250	10	2-3
	Sap	250	10	1-2
	Heart	205	25	2-3
	Sap	205	25	1-2
	Heart	175	14	11-15
	Sap	175	12	10-12

perature of 175°F. Excellent smoothness, tightness, and uniformity of thickness can be attained.

The lathe settings (7) used to cut 1/8-inch veneer were as follows: nose-bar height, 0.028 inch; horizontal bar opening, 0.110 inch; knife angle, 90°50' to 89°15'. Good 1/16-inch veneer was cut with the following settings: nose-bar height, 0.016 inch; horizontal bar opening, 0.050 to 0.055 inch; knife angle, 90°20' to 89°25'.

Horizontal bar openings smaller than the above resulted in overcompression of the veneer to the point where it failed to recover its full thickness. Larger openings resulted in loose and rough veneer.

Knife angles larger than the above resulted in corrugated veneer. Smaller knife angles resulted in veneer that was not uniform in thickness.

During the experimental cutting, considerable difficulty was encountered with those bolts that had heart rot. One bolt with a dozy center area about 12 inches in diameter could not be held in the lathe even with 8-inch chucks. In another bolt, rot was encountered at a diameter of 12 inches and cutting had to be stopped at an 11-inch diameter because small pieces broke from the bolt surface and jammed in the knife opening.

Bolts from one log that had a curly grain pattern did not cut well, particularly when heated to moderate temperatures. The quality of cutting became increasingly better at the higher temperatures. For this type of material a temperature of 210°F. would have been chosen as the optimum, except that it resulted in excessive end-checking. This curly-grained wood also cut best when the knife angle was near the lower limit of permissible angles--89°30' for 1/8-inch veneer.

In most of the test logs used in the Laboratory study knots were not encountered until a diameter of 9 inches or less was reached. Most of these knots were sound. They did not interfere with the cutting in bolts that had been heated at 175°F. A certain amount of roughness and torn grain occurred in association with the knots, because of the short grain that usually surrounded them. However, the roughness and torn grain were not worse than would occur in other hardwoods with comparable grain deformation.

In general, in cutting on the lathe the beech cut at the Laboratory displayed no unusual characteristics that are not encountered in cutting other hardwoods of comparable texture and density.

VENEER DRYING

Industry Experience

No adverse reports have been received about the drying behavior of beech in veneer form. One drier operator who had had some experience with beech reported that it dried well with respect to final moisture content, flatness, and freedom from splitting. Knots were reported to be troublesome in drying, probably because they developed shrinkage splits.

Laboratory Tests

The veneer produced experimentally was dried in a small progressive roller-conveyor type of veneer drier, at temperatures of 175° to 325°F. Although the heartwood and sapwood had approximately equal moisture contents before drying, the heartwood dried at a slower rate than the sapwood; so when sapwood and heartwood were dried on the same schedules the final moisture contents were not equal. The drying schedules used and the final moisture contents attained are given in table 2.

Splits present in the green veneer ends did not elongate on drying, but they did open in width. No new splits developed in drying. Both 1/16- and 1/8-inch veneer developed end-waviness when dried at 325°F. End-waviness was somewhat less pronounced when drying at lower temperatures, although it was still present when drying at 175°F.

Tangential (widthwise) shrinkage of veneer during drying was measured on five sheets 2 feet wide taken at various diameters in each bolt. In drying veneer to a final moisture content of 2 to 3 percent, tangential shrinkage amounted to about 10.5 percent, based on the green dimension of the sheet. It varied from a minimum of 8.2 percent to a maximum of 12.4 percent. The shrinkage was slightly greater than that generally obtained in drying yellow birch veneer to the same moisture content under comparable conditions.

VENEER GRADES & YIELDS

Grading Rules

Grades for beech veneer are not specifically mentioned in the grading rules for hardwood veneers, contained in Commercial Standard CS35-49 (3). Beech is listed, however, along with sugar maple and other dense woods in the veneer-density classification, under the caption "high-density species."

Woods in this class may be used as hardwood face veneers for technical-type plywood if not more than 1/12-inch thick, and for type-I plywood if not more than 1/8-inch thick. Both of these plywood types are intended for exterior exposure. In type-II and type-III plywoods, which are intended for use under less exacting conditions, there is no limit on veneer thickness.

Grade 1 rotary-cut maple face veneer is defined as follows in the standard: "Each face shall be matched for pleasing effect. A few small burls and bird's-eyes, a few pin knots, occasional small mineral streaks, slight discolorations, and inconspicuous small patches shall be admitted. Knots other than pin knots, worm holes, splits, and shake shall not be admitted."

Grades 2, 3, and 4, being intended for less exacting uses, are progressively more liberal with respect to knots, burls, knotholes, splits, and other defects.

Grades Obtained From Test Logs

In accordance with the above grading rules for maple veneer, the veneer cut in the Laboratory study was graded in widths down to a minimum of 6 inches for any one grade. On this basis, the yields from 24 veneer bolts were as follows:

Grade	Yield (percent)
1	48.2
2	19.8
3	10.2
4	21.8
Total	100.0

A considerable percentage of the veneer thus graded was in narrow widths. When the same veneer was graded on the assumption that all grade 1 and 2 veneer sheets would have to be at least 2 feet wide, the yield picture was changed, as follows.

Grade	Yield (percent)
1	17.8
2	24.4
3	20.3
4	37.5
Total	100.0

The difference between the two tabulations shows clearly the advantages in grade yield obtained by clipping to narrow widths and taping.

Container-Veneer Grades

In the use of veneer for containers (2), the factors considered important are: strength and soundness; absence of major defects that materially weaken the piece; freedom from knotholes more than ½ inch in diameter; absence of more than two sound knots more than 1½ inches in diameter per square foot; tightness and smoothness (veneer suitable for printing); absence of stain or mold; freedom from odor; flatness and absence of splitting; absence of cross-grain exceeding 1 in 8; and absence of defects such as knots at the end of the slat, where they would interfere with nailing.

Data are lacking as to the yield of beech veneer that would meet these qualifications. However, if log quality is held within the grade specifications, it may be expected that a large percentage of acceptable veneer will be obtained.

Veneer Yields

In the Laboratory tests, veneer yields were measured for 8 of the 10 test logs. These logs yielded two or three veneer bolts per log, 36 to 52 inches long. The net scale on these logs (International ¼-inch) was 635 board feet. The scale of usable dry veneer obtained, in sheets 6 inches or wider, was 730 board feet.

The over-run thus amounted to about 15 percent. A considerable over-run was consistently obtained from each of the logs (table 3). However, these yield figures were obtained by laboratory tests. Because of the small size of the sample, they should not be considered typical of the yield that can be obtained commercially.

Table 3.--Comparison between log scale and veneer yield of beech logs in laboratory tests

Log. No.	Average diameter at small end	Net log scale of length used (Int. ¼-inch)	Yield of dry veneer
	Inches	Bd.ft.	Bd.ft.
1	15½	85	113.5
2	15	105	112.0
4	14½	85	98.7
5	13½	70	86.4
7	13½	70	72.2
8	14½	80	94.8
9	13½	70	84.3
10	14½	70	68.2
Total	--	635	730.1

COLOR OF BEECH VENEER

The range of color in beech is considerable (8). The heartwood may be white, brownish-yellow, pink, or tan. It may contain brownish-gray streaks originating at worm holes; they are known as worm streaks. It may also contain reddish-brown to grayish-brown mineral streaks, and the sapwood may contain sap stains of a brownish or bluish nature. These discolorations are not considered harmful in regard to strength.

Decay of the wood also results in discolorations and in a weakening of the wood to the point where it is not acceptable for plywood. Decayed wood is perceptibly soft and displays yellow spots, zone lines, rot pockets, or streaks. In the incipient stages of brown rot, brown zones are seen in the heartwood and the wood is brash, but not perceptibly softened. Sapwood decay may occur together with sap stain, and it is evidenced by a uniform brownish darkening of heavily stained sapwood.

The dark heartwood of beech is sometimes called "red beech," whereas the white heartwood from some trees is call-

ed "white beech." The two-color effect obtained in cutting beech veneer is often considered objectionable for faces in furniture panels. In this respect beech is similar to yellow birch, except that birch is cut in such large quantities that heartwood and sapwood can be separated whenever wood of uniform color is desired. Figure 2 shows a sheet of beech veneer that contains both heartwood and sapwood.

In Europe as well as in this country, beech veneer and lumber are sometimes steamed at atmospheric pressures to produce a uniform heartwood color throughout both sapwood and heartwood. The wood must be sound and must have a moisture content of 50 percent or more for this treatment.

BEECH PLYWOOD

Beech plywood can be pressed with the same methods used for other hardwood species. The plywood may be made in cold or hot presses, and with a variety of glues (13).

Press times and temperatures vary with the panel construction and the glues used. Pressures may be similar to those used for birch, about 250 pounds per square inch. Some manufacturers report that they use higher pressures for beech--up to 300 pounds per square inch--and apparently with success. The species is highly resistant to compression; so such high pressures can probably be used to advantage.

Beech is among the woods that display relatively high shrinkage, especially in the tangential direction; that is, widthwise in a sheet of rotary-cut veneer (9). This has already been discussed in connection with the shrinkage of beech veneer in drying. In plywood panels this shrinkage tendency may result in face-checking and warping. Beech is more susceptible to this damage than the other hardwoods.

In making plywood of beech every precaution should be taken to minimize the warping and checking tendencies. This requires conditioning the veneer before gluing to approximately the same moisture content the panel will have later in service, observing closely the principles of balanced construction with respect to ply thickness and grain direction, reconditioning the plywood before assembly into furniture or similar products, and avoiding any sudden or great changes in moisture content.

Figure 2.--A sheet of 1/8-inch beech veneer that shows both sapwood and heartwood. Some heart rot is present in the lower right corner. This veneer was cut at a bolt diameter of 10 inches.

Exposure Tests

Three-ply and five-ply beech plywood panels, having face veneers of 1/16 and 1/8 inch, were given interior and exterior exposure tests at the Forest Products Laboratory.

In the interior tests, the panels were placed alternately in high-humidity and low-humidity atmospheres for periods of 1 month each, so that the moisture content varied alternately from about 6 percent (30 percent relative humidity) to 15 percent (80 percent humidity), or from 6 percent to 20 percent (90 percent humidity). These changes in moisture content are probably more severe than plywood would undergo in normal interior use.

After two cycles of exposure to high and low humidity the beech plywood with 1/8-inch face veneers showed a slight amount of face-checking and grain-raising. Warping was severe on the beech panels. Some delamination occurred in panels bonded with casein and extended urea-resin glues. Because of its high density and high tangential shrinkage, beech can be expected to face-check and to put high stress on glue joints when the plywood is subjected to moisture changes.

Exterior-type plywood panels were exposed outdoors on a test fence. In these tests face-checking developed after only 2 weeks of exposure. Grain-raising developed after 6 weeks. The 1/16-inch veneers performed better than the 1/8-inch faces. They developed numerous small checks, whereas the 1/8-inch veneers developed fewer--but larger--checks.

This poor performance of American beech is similar to experience with the European species. Interior and exterior exposure tests on European beech plywood at the British Forest Products Research Laboratory (10) led to the conclusion that face-checking in beech plywood is related to face-veneer thickness. Checking was found to be only slight when faces were 1/16 inch or thinner, but it was pronounced when faces were 1/8 inch thick.

In another series of tests, the face-checking tendencies of a number of species were compared. Beech and some softwoods were found to be in a class that displayed pronounced face-checking tendencies, whereas birch and similar species were intermediate in this respect, and open-textured soft tropical woods displayed the least face-checking.

Methods for dealing with this problem have already been discussed.

Glue-Line Tests

To pass the glue-line test specified in the Commercial Standard for fully waterproof hardwood plywood (3), minimum shear values of 290 pounds per square inch are required in the cyclic and boil tests. With shear-test values of this magnitude, the minimum permissible wood failure is 10 percent, and the average must be 30 percent.

The glue-line test for a water-resistant bond requires that 6- by 6-inch plywood specimens be soaked in water at room temperature for 4 hours and then be dried at room temperature for 20 hours. After two soaking-drying cycles, the specimen must not show more than 2 inches of continuous delamination in any glue line. No glue-line tests are prescribed for "dry-bond" plywood.

The values required in the Commercial Standard for waterproof and water-resistant glue lines can be obtained with beech (13).

Because beech is similar to birch, laboratory tests were made to compare beech plywood with the more generally used birch product. Casein-bonded interior type plywood panels of both species performed satisfactorily in the two-cycle soaking-and-drying test. After this test had been carried through 10 cycles--which is admittedly a severe test for any hardwood species--the differences between the two species became obvious. The beech plywood delaminated more extensively, warped more, and developed more face-checks (fig. 3). The differences between the two species are attributed to the fact that beech absorbs water faster and has a tendency to shrink and swell more tangentially than birch, for the same change in moisture content (9).

European Experience

In Europe beech has been used for plywood for many years. During World War II beech was the mainstay of the German plywood industry; the product was used for aircraft, glued-up gunstocks, molding dies, and general-use plywood (15). Much of the wartime plywood was glued with phenolic-resin glues, particularly film glue. Beech is now being glued in Europe with casein, urea, and other glues.

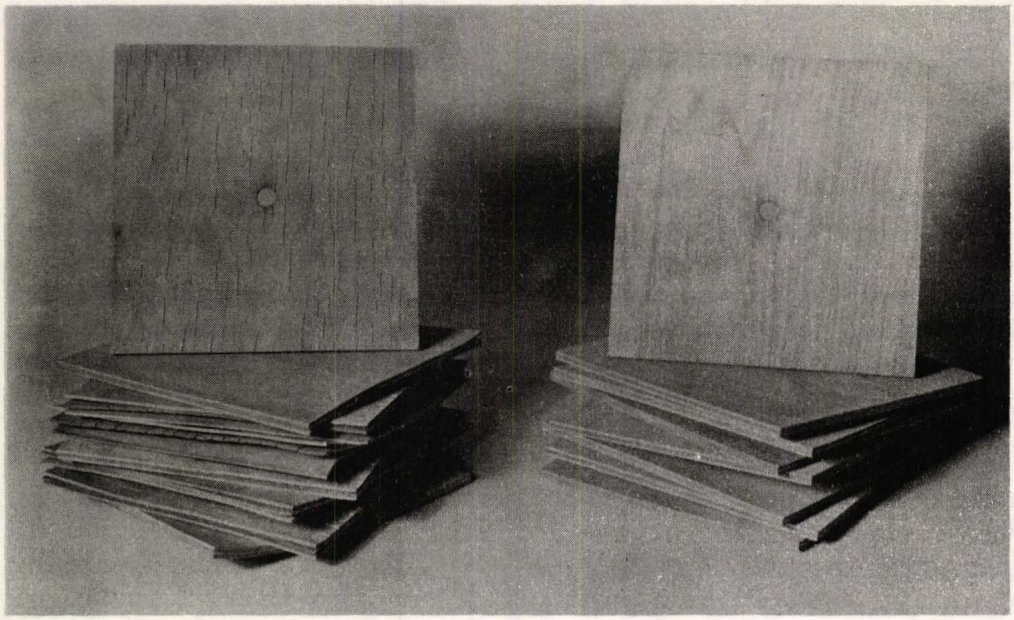

Figure 3.--Beech plywood passed the standard glue-line test of 2 cycles of alternate soaking in water and drying. After 10 cycles--a severe test for any species--the differences between beech (left) and birch (right) became obvious. Notice the differences in face-checking, warping, and delamination.

Recently large plywood panels having face veneers of European beech have been imported into Canada from Europe. These panels have cores of Scotch pine; they use 1/8-inch beech face veneers, and have a total thickness of 5/8 or 3/4 inch. It is reported that the panels take an excellent finish, are free of warping, and in general serve very well for furniture parts.

These European experiences have been mentioned to show that even such a refractory wood as beech can be used for high-grade products--if the industry is willing to make a real effort. There is no reason to doubt that American beech will perform at least as well as European beech.

USES OF BEECH VENEER & PLYWOOD

Beech has been used for veneer and plywood for many years. It is reported that 17,358,000 board feet, log scale, were used for veneer in the United States in 1929. The average annual consumption of beech veneer logs in 1929, 1931, 1935, and 1937 was 12,265,000 board feet, log scale (6). Recent figures on volume of beech veneer used for various manufactured products are given in table 4.

Table 4.--Beech veneer used in manufacture in the United States, 1948

Use	Volume
	M bd.ft. equivalent
Containers	15,858
Radios, phonographs, and sewing machines	980
Furniture	938
Match boxes	538
Fixtures	398
Housetrailers	178
Handles	117
Prefabricated houses	112
Millwork	95
Musical instruments	2
Patterns	1
Woodenware, novelties, and miscellaneous	266
Total	19,483

Source: U. S. Forest Service.

The biggest single use for beech veneer and plywood has been for containers. Beech container plywood is made as thin as 1/8 inch, with three plies of 1/24-inch veneer. In veneer form beech is used for wire-bound boxes, berry boxes, baskets, and similar containers. It lends itself well for use in bent container parts such as handles and hoops. Because beech wood is free of taste and odor, it is particularly useful for food containers.

Beech has not been used extensively for furniture in this country, either in solid or plywood form. At present

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its use is restricted largely to partially hidden furniture parts such as drawer slides, where it is used in lumber form.

In Europe and Canada beech plywood and solid lumber are used more extensively for furniture. Beech veneer has also been used in sliced form for furniture faces, but it is reported that logs suitable for slicing are rare. There are no data on manufacture or performance of sliced veneer for this country.

Beech has certain characteristics that make it particularly useful for continuous service under water. When used under such conditions, especially where friction is involved, beech has given outstanding service in lumber form. It may be expected to perform equally well in plywood form, provided the glue joints are fully waterproof, as defined in Commercial Standard CS35-49 (3).

A considerable amount of beech lumber is used for flooring, for which the wood serves well because of its hardness and high resistance to abrasion. With the increasing use of plywood for flooring, it appears that beech plywood might well be considered for this use.

The use of beech plywood for aircraft in Europe during World War II has already been mentioned. In the United States it is permitted by specifications for aircraft structural plywood (5), but other species have been favored by designers because of their greater availability.

SUMMARY

In selecting American beech logs for veneer cutting, hardwood log-grading rules now in use may be used as a guide. Care should be used in storing logs to prevent end-checking, stain, and decay. Logs should be cut up into veneer bolts in such a way as to minimize effects of sweep and crook.

Ten beech logs were experimentally cut into veneer at the U. S. Forest Products Laboratory to gain information about proper heating, cutting, and drying techniques. It was found that bolts can be properly prepared for rotary cutting by heating in water at 175°F. Higher temperatures caused excessive end-checking.

Veneer cutting did not present any unusual difficulties, nor was any pronounced difficulty encountered in drying the veneer: Widthwise shrinkage of the veneer was high; and this problem requires special attention.

In the Laboratory tests, following commonly accepted veneer-grading rules, a good yield of face veneer was obtained. The gross yield of dry veneer was highly satisfactory, with an over-run of about 15 percent (International $\frac{1}{4}$-inch rule).

Under severe interior exposure conditions, some plywood glue joints delaminated; and the plywood developed more face-checking, grain-raising, and warping than is generally encountered with most hardwoods. This again means that special attention must be paid to moisture conditions to get satisfactory performance.

Beech veneer and plywood have been used widely for containers. They can be used effectively in furniture, and some properties of the species indicate that it may be well suited for special products such as plywood flooring, plywood for continuous under-water service, and even for aircraft.

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Pulping and defiberization of beech.
Rough construction on the farm with beech.

The Northeastern Station acknowledges gratefully the effort being devoted to these problems by the many agencies and individuals who are cooperating in this project. Among the leaders in it are David B. Cook, New York State Conservation Department; Claude Bell, U.S. Forest Products Laboratory; A. H. Bishop, State University of New York, College of Forestry; and Fred Wangaard, Yale University School of Forestry. These men, along with Fred C. Simmons and C. R. Lockard of the Northeastern Station, comprise the "working committee" that is directing and coordinating the project.

The information gathered in this widespread cooperative project should be of great use to the wood-using industries of the regions where the wood of American beech is available.

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